Prince George Forest District

Documentation of
Vegetation Resources Inventory
Interim Ground Sample Inventory Analysis

PREPARED BY:
MINISTRY OF SUSTAINABLE RESOURCE MANAGEMENT
TERRESTERIAL INFORMATION BRANCH

March , 2002

Executive Summary

This report documents the Vegetation Resources Inventory (VRI) preliminary analysis that was completed for the Prince George Forest District VRI Ground Sample Inventory. The material presented in this report was made available for the current Timber Supply Review (TSR) and was developed in conjunction with staff from Ministry of Sustainable Resource Management, Terrestrial Information Branch, Prince George Region and District, and Ministry of Forests, Timber Supply Branch and Prince George Region. Funding was largely provided by Canfor through Forest Renewal. Planning support was provided by J.S.Thrower and Associates with analysis services provided Jahraus and Associates.

The report references and contains content from the previously developed "Prince George Forest District Vegetation Resources Inventory Ground Sampling Plan, April 17th 2000." A copy of this document is attached.

This analysis focused on the development of adjustment factors for height, age and volume to support the current timber supply analysis. The process used to derive these adjustments is interim (Fraser protocol) and may change in the future. In the "Fraser Protocol", the statistical adjustment of inventory attributes consists of a set of steps and assumptions used to develop and then apply adjustment factors to the FIP file attributes of height and age and the volume predicted using VDYP. The goal of the adjustment is to remove any overall bias in the inventory when compared against the VRI ground data for the attributes that are adjusted.

The steps in this adjustment process are :

1. Adjust height and age.
2. Based on the adjusted height and age, use VDYP to computed inventory volume (attribute - adjusted inventory volume)
3. Use the compiled ground volumes to then adjust the "attribute-adjusted" inventory volume.

The information contained in this report is "draft", however it is expected that this information will be used to adjust the VRI photo based inventory database files. If the stakeholders decide to complete a new photo-estimated inventory in the PG District, this analysis will have to be re-visited and appropriate weights applied to the samples.

The target population for this study is the Vegetated Treed (VT) portion of the Prince George Forest District, excluding private lands, Parks and other legally recognized Protected Areas, TFLs, and woodlots. Sample polygons were selected over the entire target population using stratified probability proportional to size with replacement (PPSWR) sampling, with the strata based on forest type (leading-species groups) and total polygon volume. The inventory was implemented in two stages. In the first stage 60 VRI sample clusters were installed in the spruce stands (pure spruce and spruce-leading stands) in the 2000 field season . In the second stage, 53 sample clusters were installed in the remainder of the VT population in the 2001 field season. NVAF sampling has not been completed in either unit.

Based on a population of interest defined as the vegetated, treed portion of the Prince George Forest District, for all stands age 0+, using loss factors, the ***overall*** volume results indicate:

i) **All Strata:** (spruce leading and all other strata) indicated a loss factor ground to inventory volume ratio of 0.839with a sampling error of 10.96%[1] at the 95% level of probability. Further review of the attached tables shows the individual strata results.

ii) **Spruce Strata only** : indicated a ground to inventory volume ratio of .789 with a sampling error of the ratio of 11.9%[2] at the 95% level of probability.

The results of this study further suggest:

i) **Inventory Age**: On average ages are over -estimated for all strata greater than age 0+. Further examination of the Fir/Pine and Spruce strata by 60 and 80 year age breaks suggests however that younger stands are substantially underestimated.

The magnitude of the age bias represented in the young stand data is cause for concern.

Review of this data by local MSRM staff (Matt Makar and Gary Westfall) suggest that the age bias is due to the selection of residual trees in the VRI ground sampling phase. The residual trees sampled in the VRI reflect "what is on the ground" however they do not correspond with the silviculture "crop tree" record information. As the silviculture record information is used in the timber supply analysis process, (managed stand second growth yield tables), it is unnecessary to apply the adjustments to the young stand population for TSR purposes. However, the adjusted young stand data can be used to describe the entire unit inventory to a common standard. For TSR purposes it is also recommended that adjustments to the inventory should be based on the inventory stand ages greater than 60 years of age. Further review of the spruce ground data sets and VRI sample procedures is also recommended.

ii) **Inventory Height:** The height data suggests similar trends as age. The same recommendations suggested for age should be applied to height.

iii) **Volume:** On average, ***loss factor*** derived volumes are over -estimated for all strata greater than age 0+. Both the overall volume impact ratios and the volume adjustment ratios, used to adjust the yield table component of the inventory, generally support this trend. Young spruce stands however suggest an underestimation in volume.

Examination of the volume impacts based on "net factored only" volumes suggest an overall increase in volume compared to the loss factor derived volumes. The upward pressure suggested by this data must however be viewed with caution. Net factoring only, without NVAF sampling will tend to over-predict volume. In order to realize the potential increase in volume presented in the net factored study it is recommended that stakeholders complete the NVAF component of the VRI ground sample inventory.

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[1] Net Factoring only ratio 0.982 with a sampling error of the ratio 10.1% @ 95% level of probability. age breaks ignored. CW sample 36 excluded.

[2] Net Factoring only ratio 0.936 with a sampling error of the ratio 11.2% @ 95% level of probability. age breaks ignored. CW sample 36 excluded

The total contract costs to date on this project are approximately $ 250,000 for field sampling and $10,000 for planning and analysis.

Prince George TSA DRAFT VRI Adjustment Factors

Analysis Notes:

- Spruce samples (originally compiled in the spring of 2001) were recompiled using the current "regression-fix" compiler. In addition the heights and ages for ratio development were re-analysed to be consistent with the current methodology. Hence the adjustment factors for the spruce stratum will differ compared with those produced in the spring of 2001)
- Inventory ages and height used in the development of the adjustment ratios were projected to year of field sampling. For project 024S, inventory data was projected to 2000 whereas project 0241 samples were projected to 2001.
- NVAF sampling was not completed in this unit
- Volume utilization was at 17.5 cm+ dbh net dwb except 12.5cm+ dbh net dwb where the inventory leading species was lodgepole pine.
- Volumes were compiled using loss factors (LF) and net factoring (NF). Adjustment ratios based on both compiled volumes (LF and NF) are provided.
- Sample 36 was an old cedar stand. Loss factors resulted in a large volume reduction for the cedar component of the stand. Because there was no observed decay, net factoring resulted in very little volume reduction (see Bob Krahn's January 25, 2002 e-mail for details). Due to the extreme difference between loss factor and net factored volumes, analysis was done with and without this sample.
- Adjustment based on a 60 year and an 80 year age break for the FIR/PINE and the SPRUCE strata were provided. There were insufficient samples in the Deciduous stratum to sub-stratify by age. Only one sample in the Balsam/Hemlock/Cedar stratum was less than 80 years of age. Age sub-stratification of this stratum was not examined.

Table 1: Age and Height Means and Ratios by species strata

Stratum	*n*	*Ground height*	*Map height*	*Height ratio*	*n*	*Ground age*	*Map age*	*Age ratio*
Deciduous[3]	4	20.612	21.025	0.980	4	60.845	73.5	0.828
Balsam, hemlock, cedar[4]	19	21.469	20.563	1.044	18	153.74	192.444	0.799
Balsam, hemlock, cedar (sample 36 excluded)[5]	18	20.543	19.739	1.041	18	153.74	192.444	0.799
Fir, pine	27	19.177	18.87	1.016	27	90.432	91.444	0.989
Map age >60	19	24.11	24.358	0.990	19	117.841	122.263	0.964
Map age <=60	8	7.463	5.838	1.278	8	25.335	18.25	1.388
Map age >80	15	25.109	26.013	0.965	15	130.509	136.333	0.957
Map age <=80	12	11.763	9.942	1.183	12	40.336	35.333	1.142
Spruce	52	21.437	22.787	0.941	54	128.501	147.056	0.874
Map age >60	40	25.906	28.67	0.904	41	156.89	187.634	0.836
Map age <=60	12	6.539	3.175	2.060	13	38.966	19.077	2.043
Map age >80	39	26.101	28.854	0.905	40	159.042	190.325	0.836
Map age <=80	13	7.444	4.585	1.624	14	41.239	23.429	1.760

[3] Only one deciduous sample was greater than 80 years of age hence no age post-stratification is presented.
[4] Only one Balsam, hemlock, cedar sample was less than 80 years of age hence no age post-stratification is presented.
[5] Sample 36 showed an extreme difference between the loss factor volume (103 m3/ha) and the net factored volume (1128 m3/ha). This sample has a significant impact on the volume ratios hence analysis with and without this sample is provided.

Table 2: Volume Means and Ratios by species strata for LOSS FACTOR VOLUMES (LF) (17.5cm+ net dwb except 12.5cm+ dbh where inventory indicates lodgepole pine leading)

Stratum	*n*	*Ground vol/ha (LF)*	*Unadjusted Inventory vol/ha [1]*	*Attribute-adjusted inventory vol/ha[6] [2]*	*Overall volume impact (LF)*	*Volume adjustment ratio (LF)*
Deciduous	5	54.304	85.94	69.74	0632	0.779
Balsam, hemlock, cedar	21	153.267	185.205	199.414	0.828	0.769
Balsam, hemlock, cedar (sample 36 excluded)[7]	20	155.804	173.63	184.6	0.897	0.844
Fir, pine	28	198.48	221.782	226.964	0.895	0.874
Map age >60	20	271.899	300.535	293.865	0.905	0.925
Map age <=60	8	14.935	24.9	35.45	0.600	0.421
Map age >80	15	317.532	343.893	323.473	0.923	0.982
Map age <=80	13	61.113	80.885	109.369	0.756	0.559
Spruce	60	172.428	218.59	198.633	0.789	0.868
Map age >60	43	237.185	304.249	260.007	0.780	0.912
Map age <=60	17	8.63	1.924	17.835	4.485	0.484
Map age >80	42	238.768	307.74	263.579	0.776	0.906
Map age <=80	18	17.633	10.572	31.661	1.668	0.557

[6] Based on Table 1 age and height adjustments

[7] Sample 36 showed an extreme difference between the loss factor volume (103 m3/ha) and the net factored volume (1128 m3/ha). This sample has a significant impact on the volume ratios hence analysis with and without this sample is provided.

Table 3: Volume Means and Ratios by species strata for NET FACTORED VOLUMES (NF) (17.5cm+ net dwb except 12.5cm+ dbh where inventory indicates lodgepole pine leading)

Stratum	n	Ground vol/ha (NF)	Unadjusted Inventory vol/ha [1]	Attribute-adjusted inventory vol/ha[8] [2]	Overall volume impact (NF)	Volume adjustment ratio (NF)
Deciduous	5	86.992	85.94	69.74	1.012	1.247
Balsam, hemlock, cedar	21	230.839	185.205	199.414	1.246	1.158
Balsam, hemlock, cedar (sample 36 excluded)[9]	20	185.998	173.63	184.6	1.071	1.008
Fir, pine	28	217.722	221.782	226.964	0.982	0.959
Map age >60	20	299.296	300.535	293.865	0.996	1.018
Map age <=60	8	13.787	24.9	35.45	0.554	0.389
Map age >80	15	346.689	343.893	323.473	1.008	1.072
Map age <=80	13	68.914	80.885	109.369	0.852	0.630
Spruce	60	204.696	218.59	198.633	0.936	1.031
Map age >60	43	281.953	304.249	260.007	0.927	1.084
Map age <=60	17	9.282	1.924	17.835	4.824	0.520
Map age >80	42	284.62	307.74	263.579	0.925	1.080
Map age <=80	18	18.206	10.572	31.661	1.722	0.575

[8] Based on Table 1 age and height adjustments

[9] Sample 36 showed an extreme difference between the loss factor volume (103 m3/ha) and the net factored volume (1128 m3/ha). This sample has a significant impact on the volume ratios hence analysis with and without this sample is provided.

Age relationships and residuals

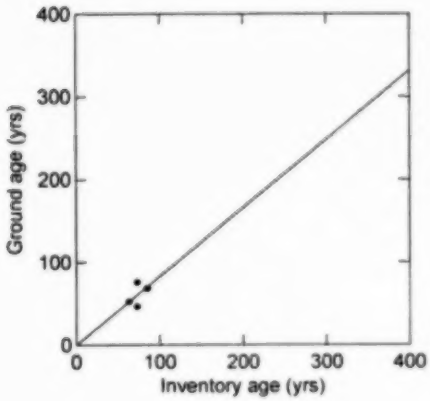

Fig 1: Ground vs. inventory age for DECIDUOUS stratum. Line represents adjustment ratio.

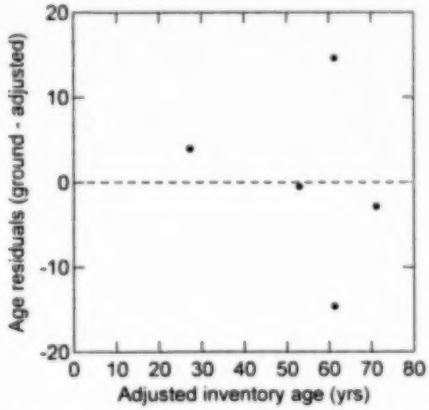

Fig 2: Age residual (ground age – adjusted inventory age) versus adjusted inventory age for DECIDUOUS stratum. Horizontal line represents zero bias. Points above the line represent underestimates whereas points below the line represent overestimates.

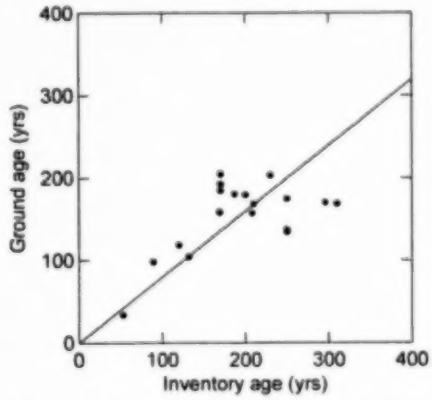

Fig 3: Ground vs. inventory age for BHC stratum. Line represents adjustment ratio.

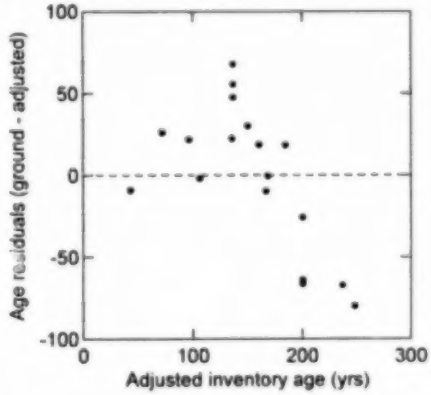

Fig 4: Age residual (ground age – adjusted inventory age) versus adjusted inventory age for BHC stratum. Horizontal line represents zero bias. Points above the line represent underestimates whereas points below the line represent overestimates.

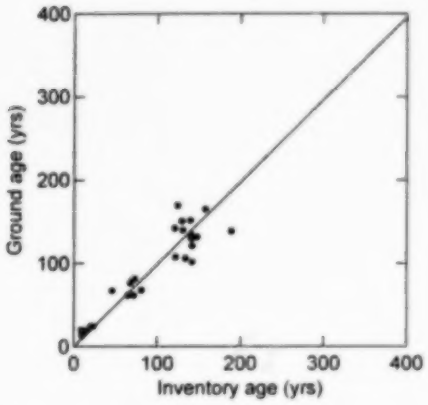

Fig 5. Ground vs. inventory age for FIR/PINE stratum. Line represents adjustment ratio.

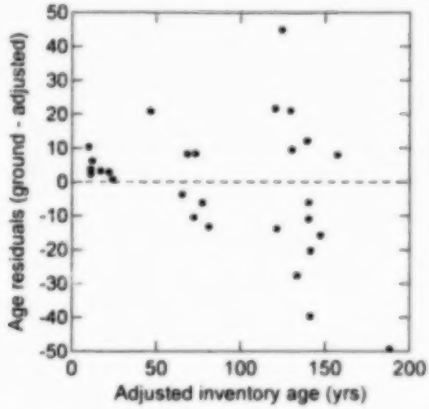

Fig 6. Age residual (ground age – adjusted inventory age) versus adjusted inventory age for FIR/PINE stratum. Horizontal line represents zero bias. Points above the line represent underestimates whereas points below the line represent overestimates.

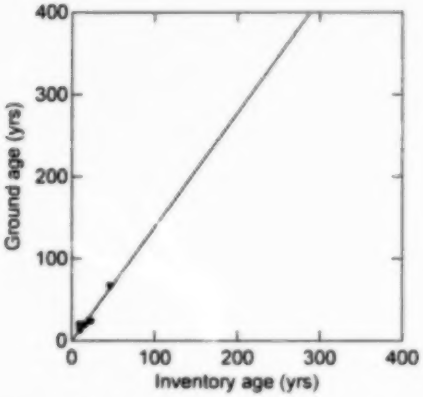

Fig 7. Ground vs. inventory age for FIR/PINE stratum, inventory age <=60. Line represents adjustment ratio.

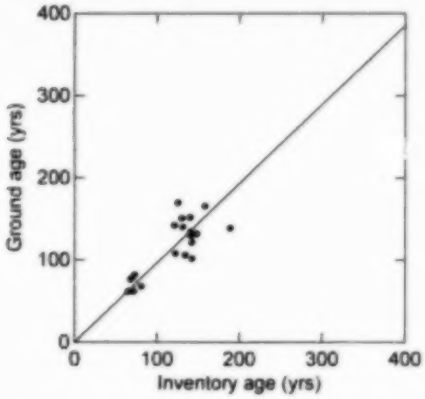

Fig 8. Ground vs. inventory age for FIR/PINE stratum, inventory age >60. Line represents adjustment ratio.

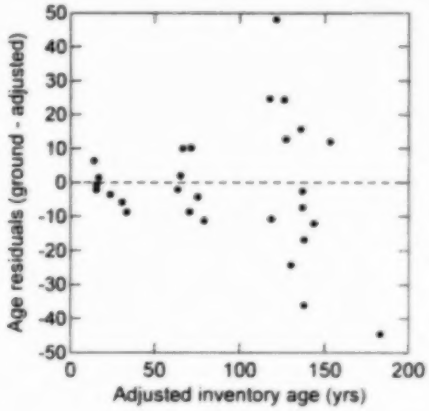

Fig 9. Age residual (ground age – adjusted inventory age) versus adjusted inventory age for FIR/PINE stratum, with 60 year age break. Horizontal line represents zero bias. Points above the line represent underestimates whereas points below the line represent overestimates.

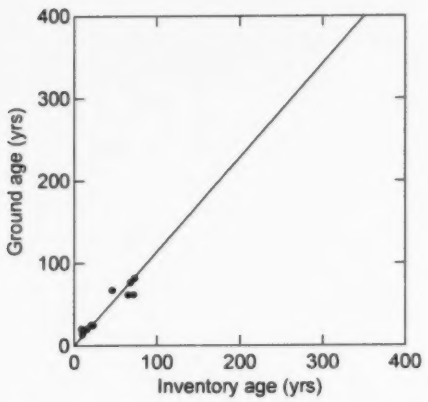

Fig 10: Ground vs. inventory age for FIR/PINE stratum, inventory age <=80. Line represents adjustment ratio.

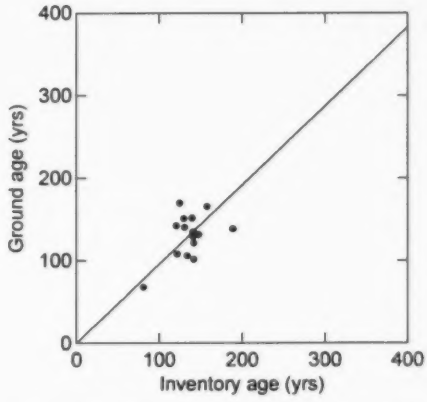

Fig 11: Ground vs. inventory age for FIR/PINE stratum, inventory age >80. Line represents adjustment ratio.

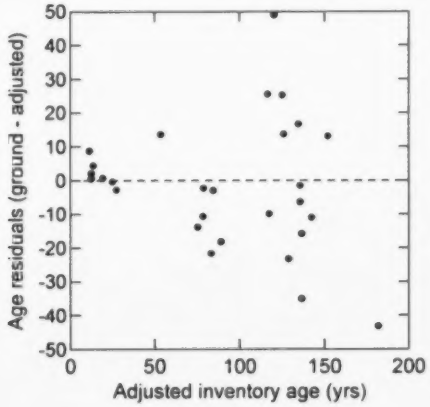

Fig 12. Age residual (ground age – adjusted inventory age) versus adjusted inventory age for FIR/PINE stratum, with 80 year age break. Horizontal line represents zero bias. Points above the line represent underestimates whereas points below the line represent overestimates.

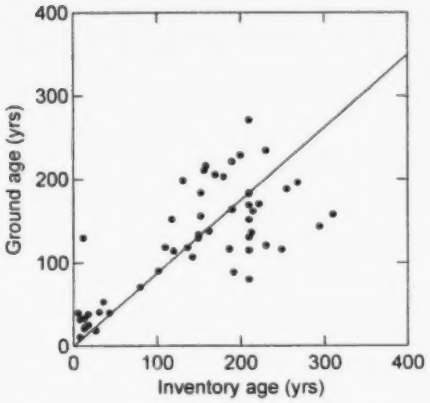

Fig 13: Ground vs. inventory age for SPRUCE stratum. Line represents adjustment ratio.

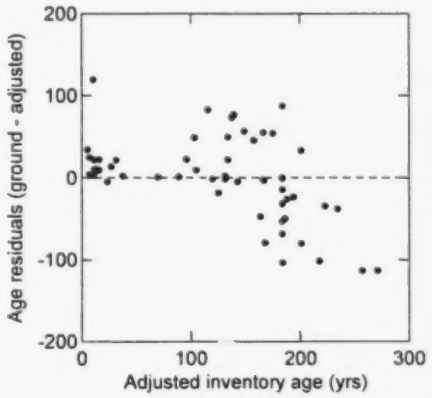

Fig 14: Age residual (ground age – adjusted inventory age) versus adjusted inventory age for SPRUCE stratum. Horizontal line represents zero bias. Points above the line represent underestimates whereas points below the line represent overestimates.

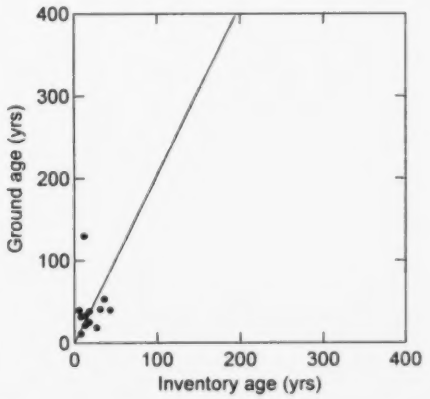

Fig 15: Ground vs. inventory age for SPRUCE stratum, inventory age <=60. Line represents adjustment ratio.

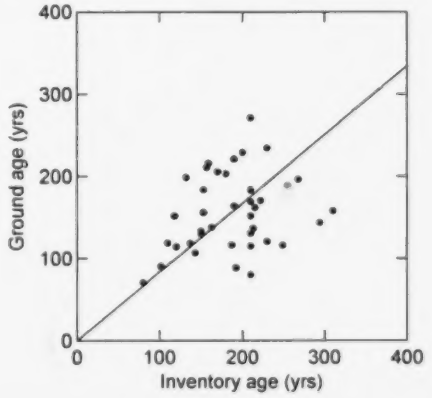

Fig 16: Ground vs. inventory age for SPRUCE stratum, inventory age >60. Line represents adjustment ratio.

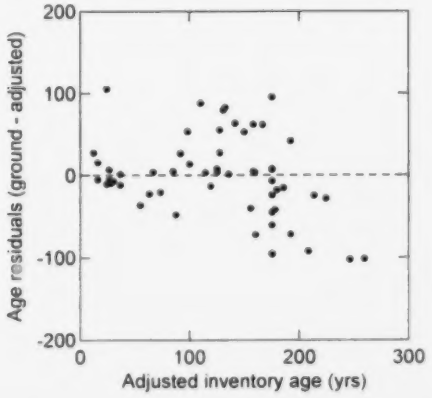

Fig 17: Age residual (ground age – adjusted inventory age) versus adjusted inventory age for SPRUCE stratum, with 60 year age break. Horizontal line

represents zero bias. Points above the line represent underestimates whereas points below the line represent overestimates.

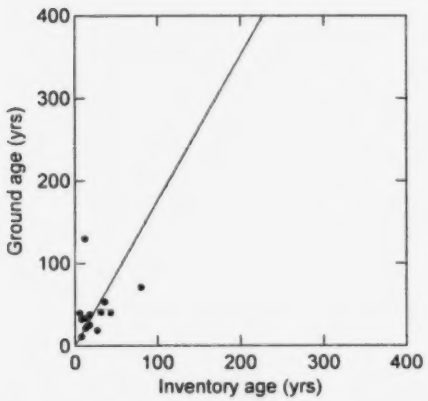

Fig 18: Ground vs. inventory age for SPRUCE stratum, inventory age <=80. Line represents adjustment ratio.

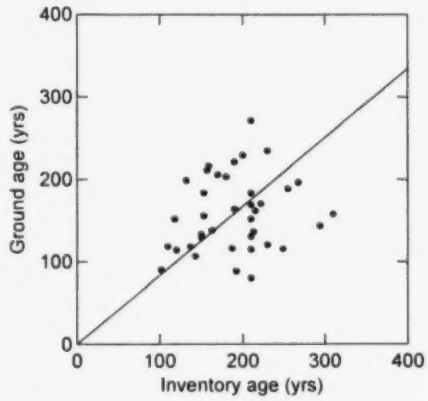

Fig 19: Ground vs. inventory age for SPRUCE stratum, inventory age >80. Line represents adjustment ratio.

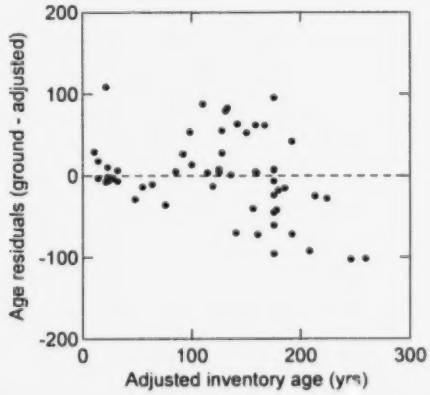

Fig 20: Age residual (ground age – adjusted inventory age) versus adjusted inventory age for SPRUCE stratum, with 80 year age break. Horizontal line represents zero bias. Points above the line represent underestimates whereas points below the line represent overestimates.

Height relationships and residuals

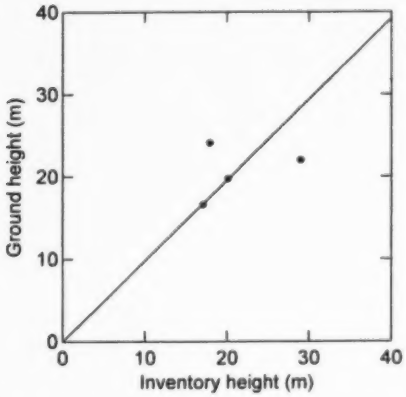

Fig 21: Ground vs. inventory height for DECIDUOUS stratum. Line represents adjustment ratio.

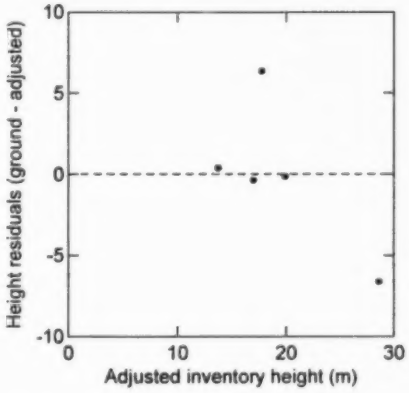

Fig 22: Height residual (ground ht – adjusted inventory ht) versus adjusted inventory height for DECIDUOUS stratum. Horizontal line represents zero bias. Points above the line represent underestimates whereas points below the line represent overestimates.

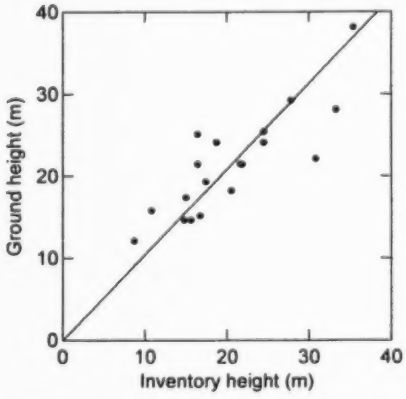

Fig 23: Ground vs. inventory height for BHC stratum. Line represents adjustment ratio.

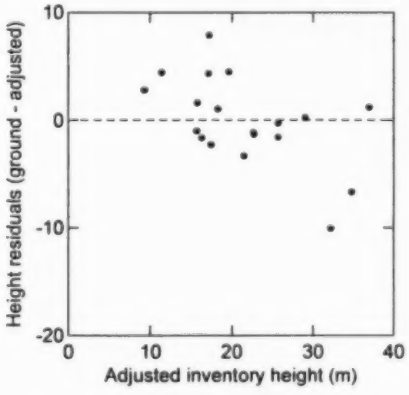

Fig 24: Height residual (ground ht – adjusted inventory ht) versus adjusted inventory height for BHC stratum. Horizontal line represents zero bias. Points above the line represent underestimates whereas points below the line represent overestimates.

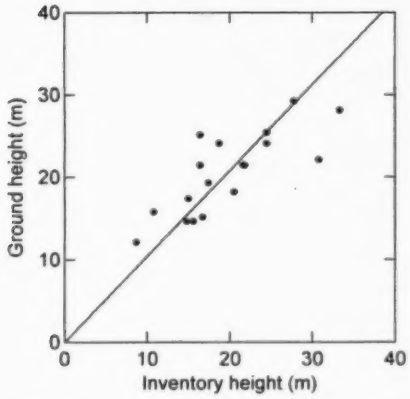

Fig 25: Ground vs. inventory height for BHC stratum excluding sample #36. Line represents adjustment ratio.

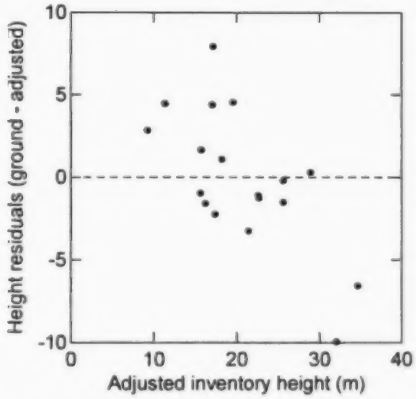

Fig 26: Height residual (ground ht – adjusted inventory ht) versus adjusted inventory height for BHC stratum excluding sample #36.

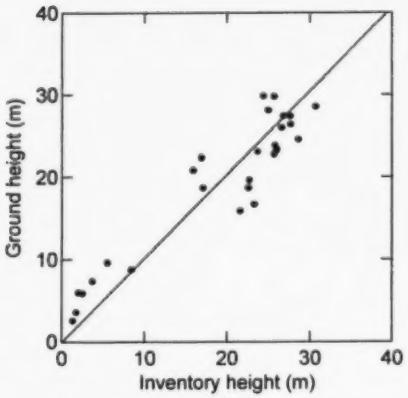

Fig 27: Ground vs. inventory height for FIR/PINE stratum. Line represents adjustment ratio.

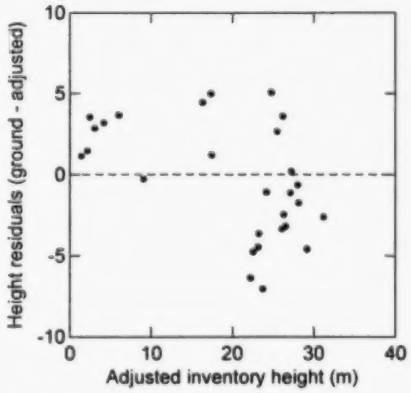

Fig 28: Height residual (ground ht – adjusted inventory ht) versus adjusted inventory height for FIR/PINE stratum. Horizontal line represents zero bias. Points above the line represent underestimates whereas points below the line represent overestimates.

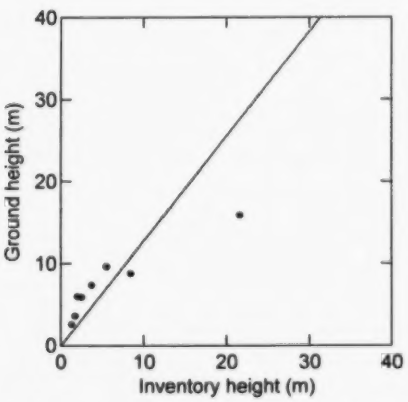

Fig 29: Ground vs. inventory height for FIR/PINE stratum, inventory age <=60. Line represents adjustment ratio.

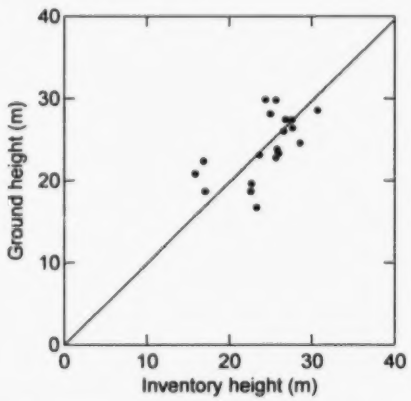

Fig 30: Ground vs. inventory height for FIR/PINE stratum, inventory age >60. Line represents adjustment ratio.

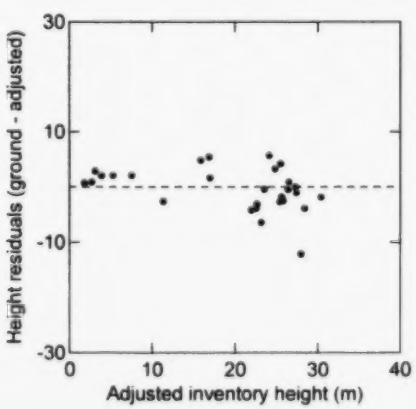

Fig 31: Height residual (ground ht – adjusted inventory ht) versus adjusted inventory height for FIR/PINE stratum with 60 year age break. Horizontal line

represents zero bias. Points above the line represent underestimates whereas points below the line represent overestimates.

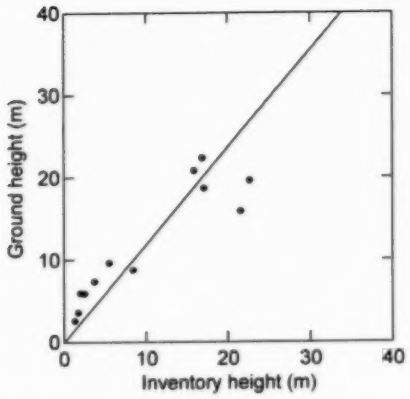

Fig 32: Ground vs. inventory height for FIR/PINE stratum, inventory age <=80. Line represents adjustment ratio.

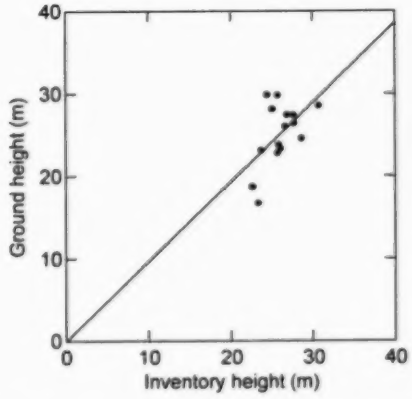

Fig 33: Ground vs. inventory height for FIR/PINE stratum, inventory age >80. Line represents adjustment ratio.

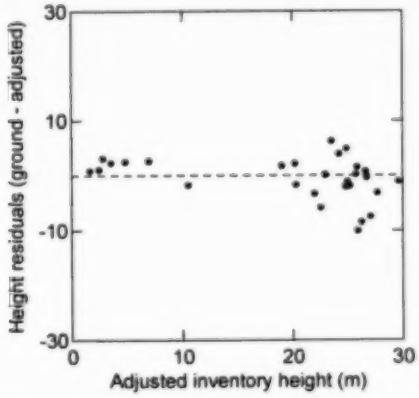

Fig 34: Height residual (ground ht – adjusted inventory ht) versus adjusted inventory height for FIR/PINE stratum with 80 year age break. Horizontal line represents zero bias. Points above the line represent underestimates whereas points below the line represent overestimates.

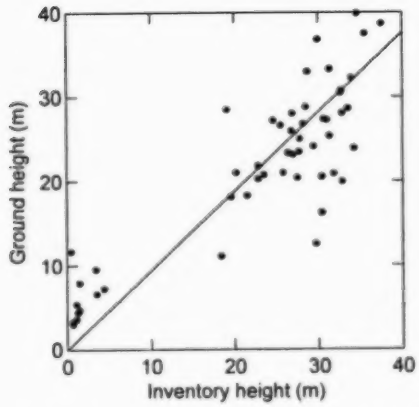

Fig 35: Ground vs. inventory height for SPRUCE stratum. Line represents adjustment ratio.

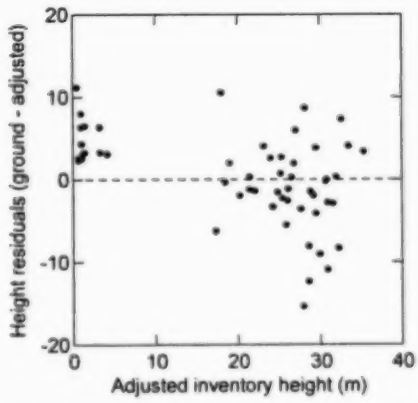

Fig 36: Height residual (ground ht – adjusted inventory ht) versus adjusted inventory height for SPRUCE stratum. Horizontal line represents zero bias. Points above the line represent underestimates whereas points below the line represent overestimates.

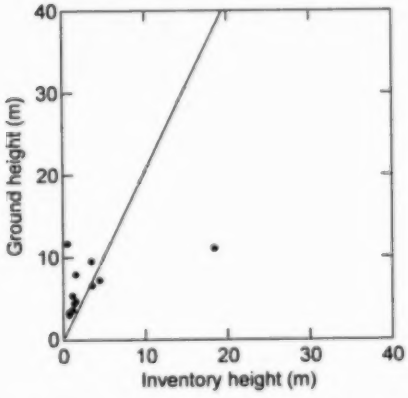

Fig 37: Ground vs. inventory height for SPRUCE stratum, inventory age <=60. Line represents adjustment ratio.

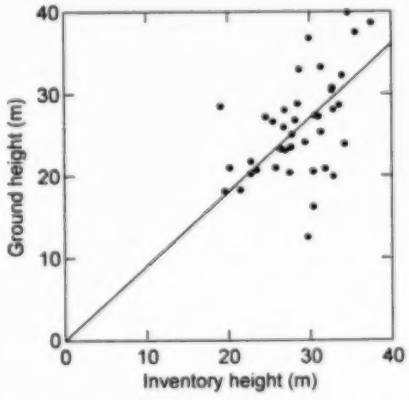

Fig 38: Ground vs. inventory height for SPRUCE stratum, inventory age >60. Line represents adjustment ratio.

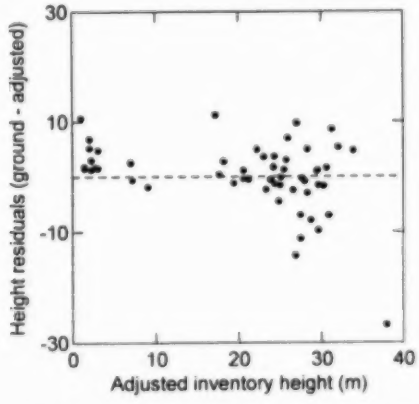

Fig 39: Height residual (ground ht – adjusted inventory ht) versus adjusted inventory height for SPRUCE stratum with 60 year age break. Horizontal line

represents zero bias. Points above the line represent underestimates whereas points below the line represent overestimates.

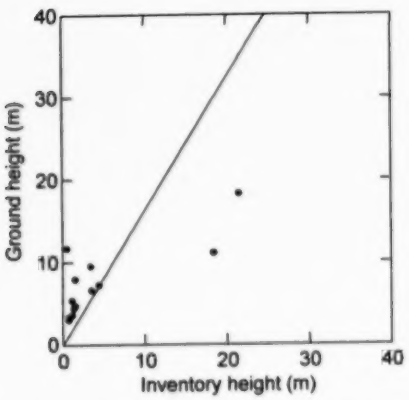

Fig 40: Ground vs. inventory height for SPRUCE stratum, inventory age <=80. Line represents adjustment ratio.

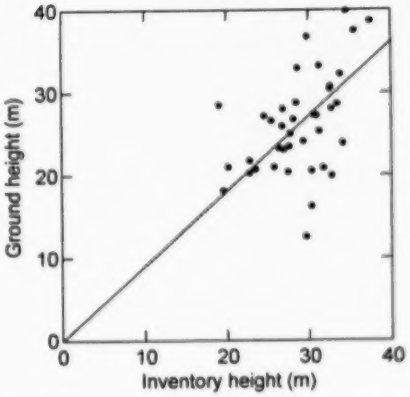

Fig 41: Ground vs. inventory height for SPRUCE stratum, inventory age >80. Line represents adjustment ratio.

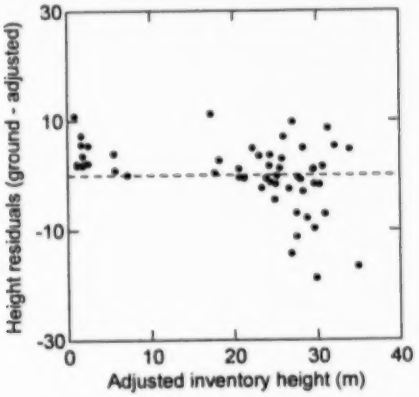

Fig 42: Height residual (ground ht – adjusted inventory ht) versus adjusted inventory height for SPRUCE stratum with 80 year age break. Horizontal line represents zero bias. Points above the line represent underestimates whereas points below the line represent overestimates.

Volume relationships and residuals

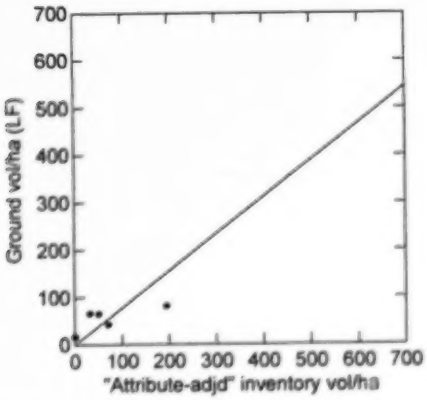

Fig 43: Ground vs. "attribute-adjusted" inventory vol/ha for DECIDUOUS stratum. Line represents adjustment ratio.

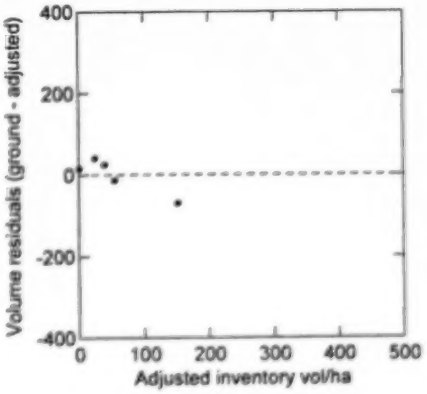

Fig 44: Volume residual (ground – adjusted inventory) versus adjusted inventory vol/ha for DECIDUOUS stratum. Horizontal line represents zero bias. Points above the line represent underestimates whereas points below the line represent overestimates.

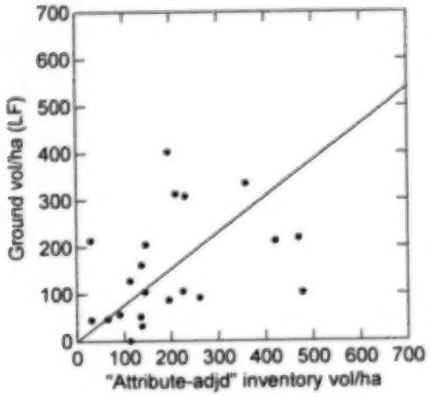

Fig 45: Ground vs. "attribute-adjusted" inventory vol/ha for BHC stratum. Line represents adjustment ratio.

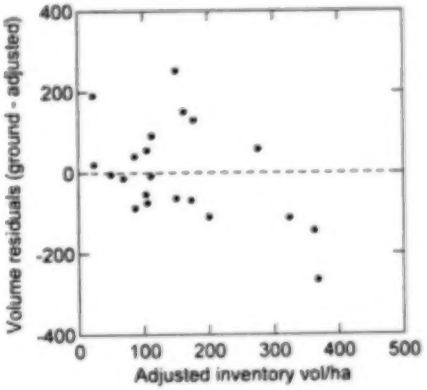

Fig 46: Volume residual (ground – adjusted inventory) versus adjusted inventory vol/ha for BHC stratum. Horizontal line represents zero bias. Points above the line represent underestimates whereas points below the line represent overestimates.

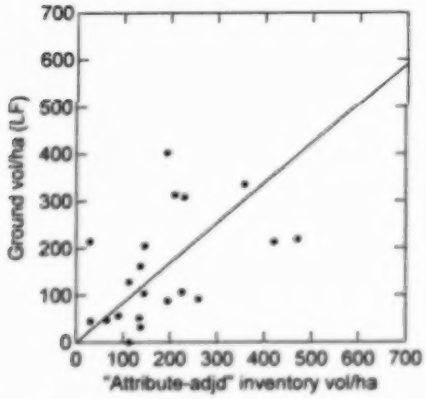

Fig 47. Ground vs. "attribute-adjusted" inventory vol/ha for BHC stratum excluding sample #36. Line represents adjustment ratio.

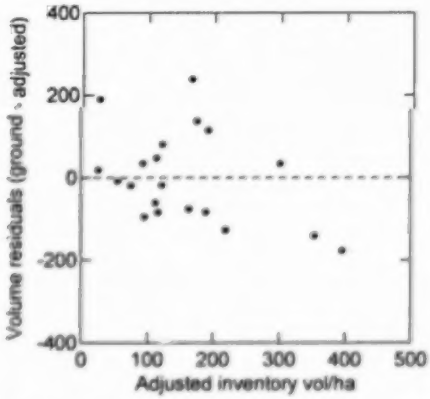

Fig 48. Volume residual (ground – adjusted inventory) versus adjusted inventory vol/ha for BHC stratum excluding sample #36.

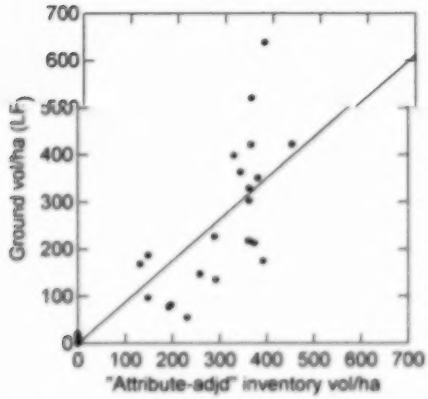

Fig 49. Ground vs. "attribute-adjusted" inventory vol/ha for FIR/PINE stratum. Line represents adjustment ratio.

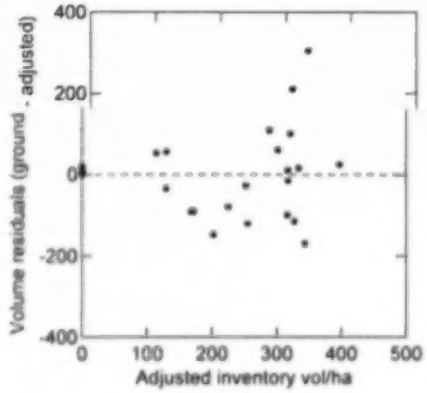

Fig 50. Volume residual (ground – adjusted inventory) versus adjusted inventory vol/ha for FIR/PINE stratum. Horizontal line represents zero bias. Points above the line represent underestimates whereas points below the line represent overestimates.

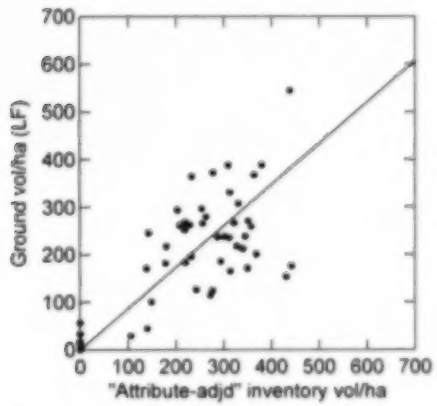

Fig 51. Ground vs. "attribute-adjusted" inventory vol/ha for SPRUCE stratum. Line represents adjustment ratio.

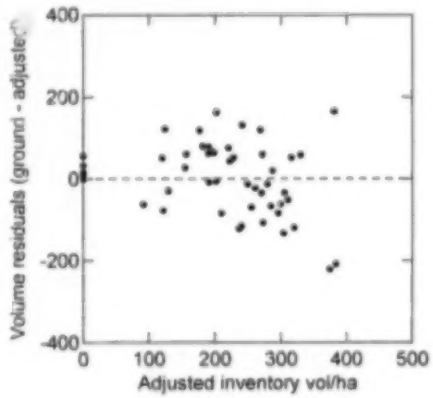

Fig 52. Volume residual (ground – adjusted inventory) versus adjusted inventory vol/ha for SPRUCE stratum. Horizontal line represents zero bias. Points above the line represent underestimates whereas points below the line represent overestimates.

Volume residuals as a function of adjusted age

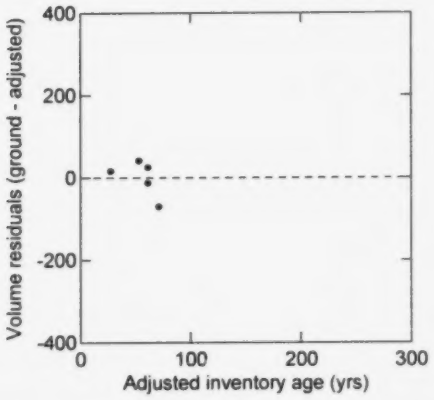

Fig 53: Volume residual (ground – adjusted inventory) versus adjusted inventory age for DECIDUOUS stratum. Horizontal line represents zero bias. Points above the line represent underestimates whereas points below the line represent overestimates.

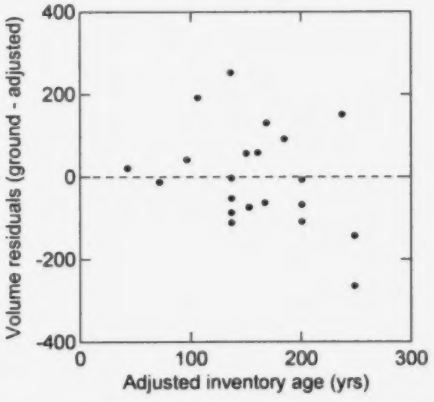

Fig 54: Volume residual (ground – adjusted inventory) versus adjusted inventory age for BHC stratum. Horizontal line represents zero bias. Points above the line represent underestimates whereas points below the line represent overestimates.

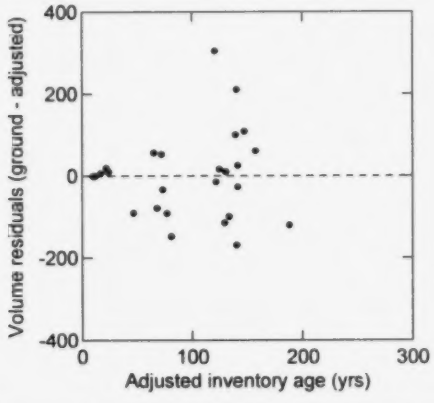

Fig 55: Volume residual (ground – adjusted inventory) versus adjusted inventory age for PINE/FIR stratum. Horizontal line represents zero bias. Points above the line represent underestimates whereas points below the line represent overestimates.

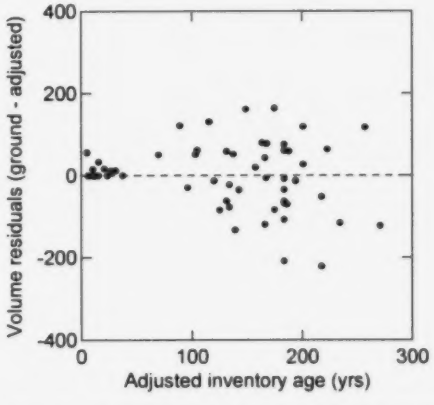

Fig 56: Volume residual (ground – adjusted inventory) versus adjusted inventory age for SPRUCE stratum. Horizontal line represents zero bias. Points above the line represent underestimates whereas points below the line represent overestimates.

Volume relationships and residuals for Fir/Pine stratum with 60 yr age break

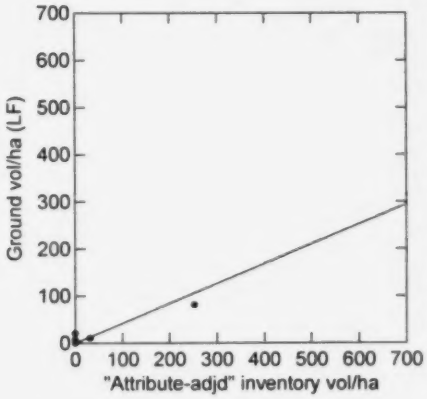

Fig 57: Ground vs. "attribute-adjusted" inventory vol/ha for FIR/PINE stratum, inventory age <=60. Line represents adjustment ratio.

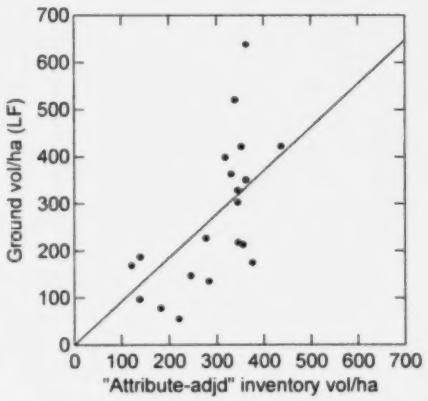

Fig 58: Ground vs. "attribute-adjusted" inventory vol/ha for FIR/PINE stratum, inventory age >60. Line represents adjustment ratio.

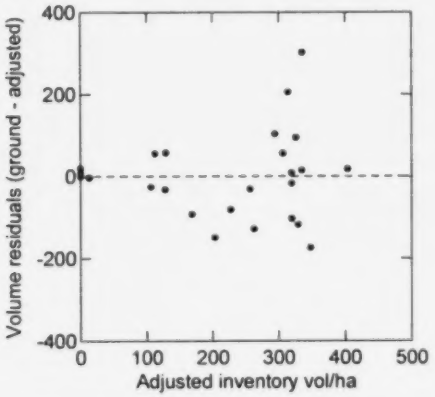

Fig 59: Volume residual (ground – adjusted inventory) versus adjusted inventory vol/ha for PINE/FIR stratum with 60 year age break. Horizontal line represents zero bias. Points above the line represent underestimates whereas points below the line represent overestimates.

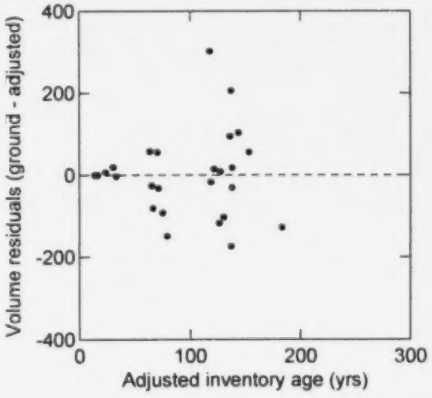

Fig 60: Volume residual (ground – adjusted inventory) versus adjusted inventory age for PINE/FIR stratum with 60 year age break. Horizontal line represents zero bias. Points above the line represent underestimates whereas points below the line represent overestimates.

Volume relationships and residuals for Fir/Pine stratum with 80 yr age break

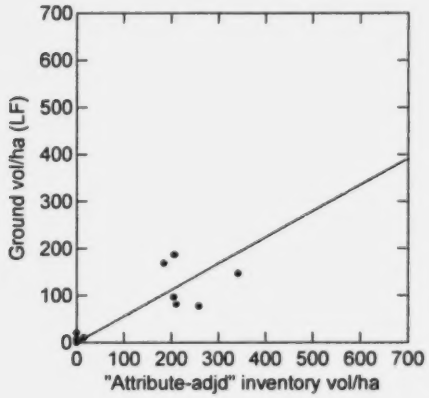

Fig 61: Ground vs. "attribute-adjusted" inventory vol/ha for FIR/PINE stratum, inventory age <=80. Line represents adjustment ratio.

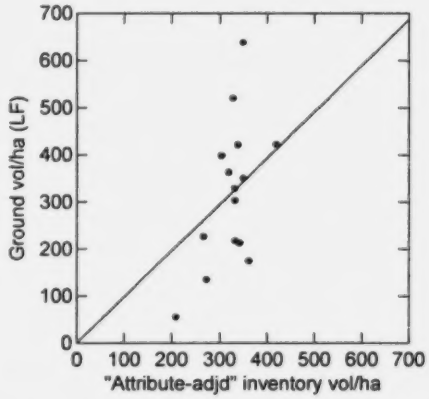

Fig 62: Ground vs. "attribute-adjusted" inventory vol/ha for FIR/PINE stratum, inventory age >80. Line represents adjustment ratio.

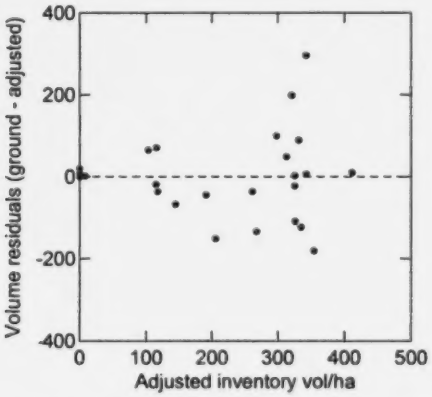

Fig 63: Volume residual (ground – adjusted inventory) versus adjusted inventory vol/ha for PINE/FIR stratum with 80 year age break. Horizontal line represents zero bias. Points above the line represent underestimates whereas points below the line represent overestimates.

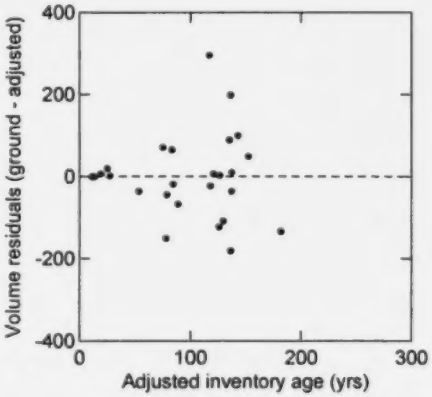

Fig 64: Volume residual (ground – adjusted inventory) versus adjusted inventory age for PINE/FIR stratum with 80 year age break. Horizontal line represents zero bias. Points above the line represent underestimates whereas points below the line represent overestimates.

Volume relationships and residuals for Spruce stratum with 60 yr age break

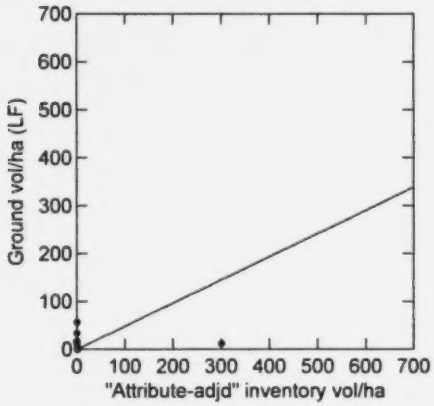

Fig 65: Ground vs. "attribute-adjusted" inventory vol/ha for SPRUCE stratum, inventory age <=60. Line represents adjustment ratio.

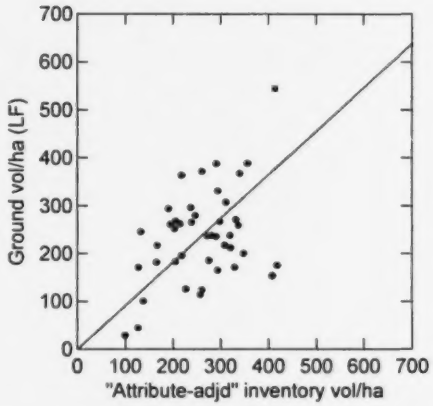

Fig 66: Ground vs. "attribute-adjusted" inventory vol/ha for SPRUCE stratum, inventory age >60. Line represents adjustment ratio.

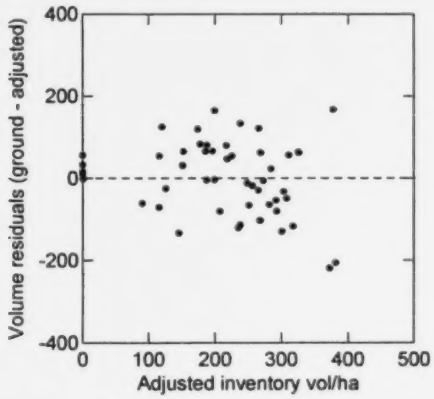

Fig 67: Volume residual (ground – adjusted inventory) versus adjusted inventory vol/ha for SPRUCE stratum with 60 year age break. Horizontal line represents zero bias. Points above the line represent underestimates whereas points below the line represent overestimates.

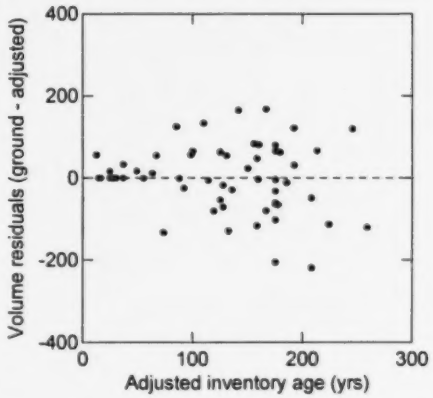

Fig 68: Volume residual (ground – adjusted inventory) versus adjusted inventory age for SPRUCE stratum with 60 year age break. Horizontal line represents zero bias. Points above the line represent underestimates whereas points below the line represent overestimates.

Volume relationships and residuals for Spruce stratum with 80 yr age break

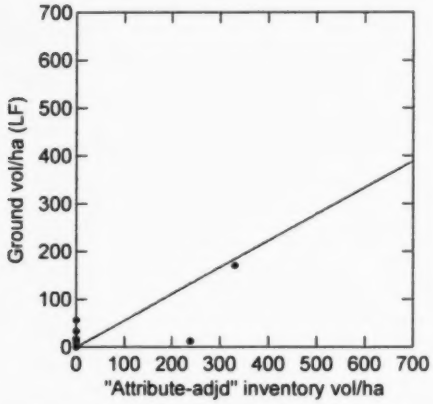

Fig 69: Ground vs. "attribute-adjusted" inventory vol/ha for SPRUCE stratum, inventory age <=80. Line represents adjustment ratio.

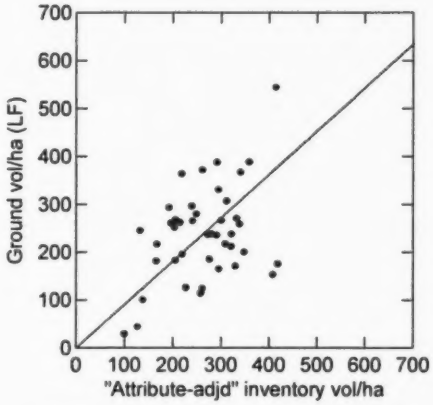

Fig 70: Ground vs. "attribute-adjusted" inventory vol/ha for SPRUCE stratum, inventory age >80. Line represents adjustment ratio.

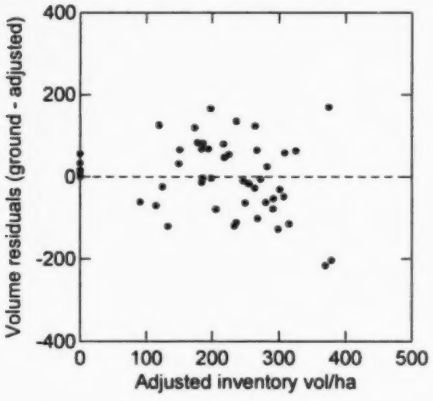

Fig 71: Volume residual (ground – adjusted inventory) versus adjusted inventory vol/ha for SPRUCE stratum with 80 year age break. Horizontal line represents zero bias. Points above the line represent underestimates whereas points below the line represent overestimates.

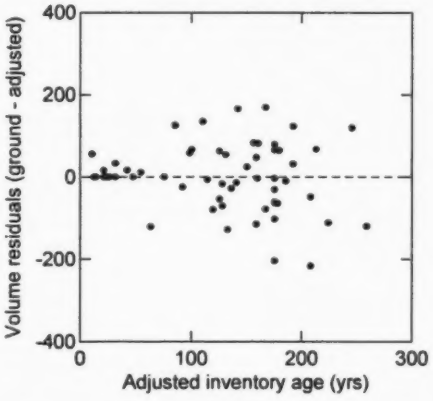

Fig 72: Volume residual (ground – adjusted inventory) versus adjusted inventory age for SPRUCE stratum with 80 year age break. Horizontal line represents zero bias. Points above the line represent underestimates whereas points below the line represent overestimates.